



NASA GEOS Composition Forecast system: “GEOS-CF”

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NASA Global Modeling and Assimilation Office (GMAO)

In collaboration with:

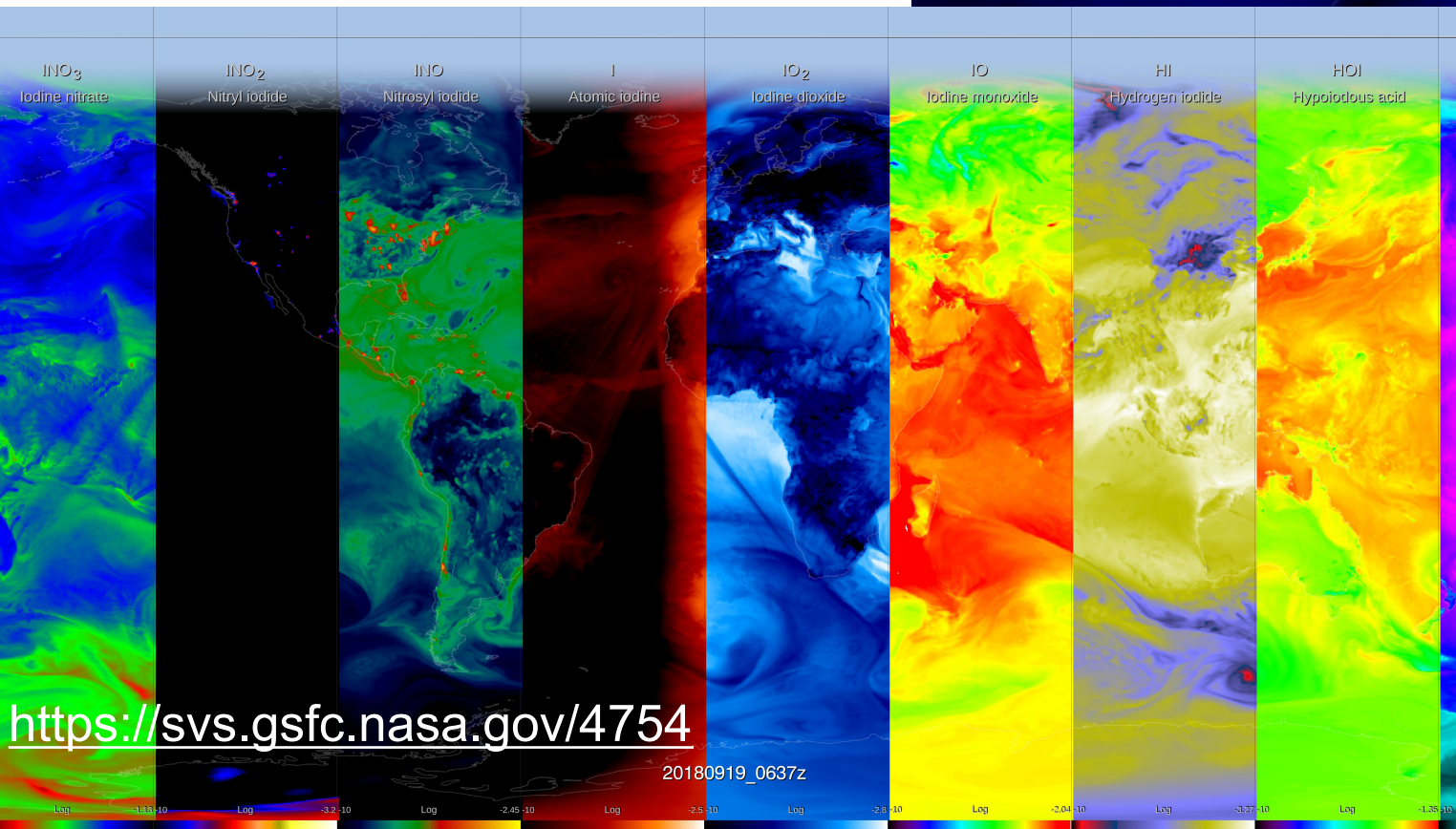
NASA GMAO: Christoph Keller, Pamela Wales, Larry Coy, Kris Wargan, Callum Wayman, Lesley Ott, Steven Pawson

Atmospheric Chemistry and Dynamics Lab: Bryan Duncan, Sarah Strode, Junhua Liu, Julie Nicely, Dan Anderson, Eric Fleming

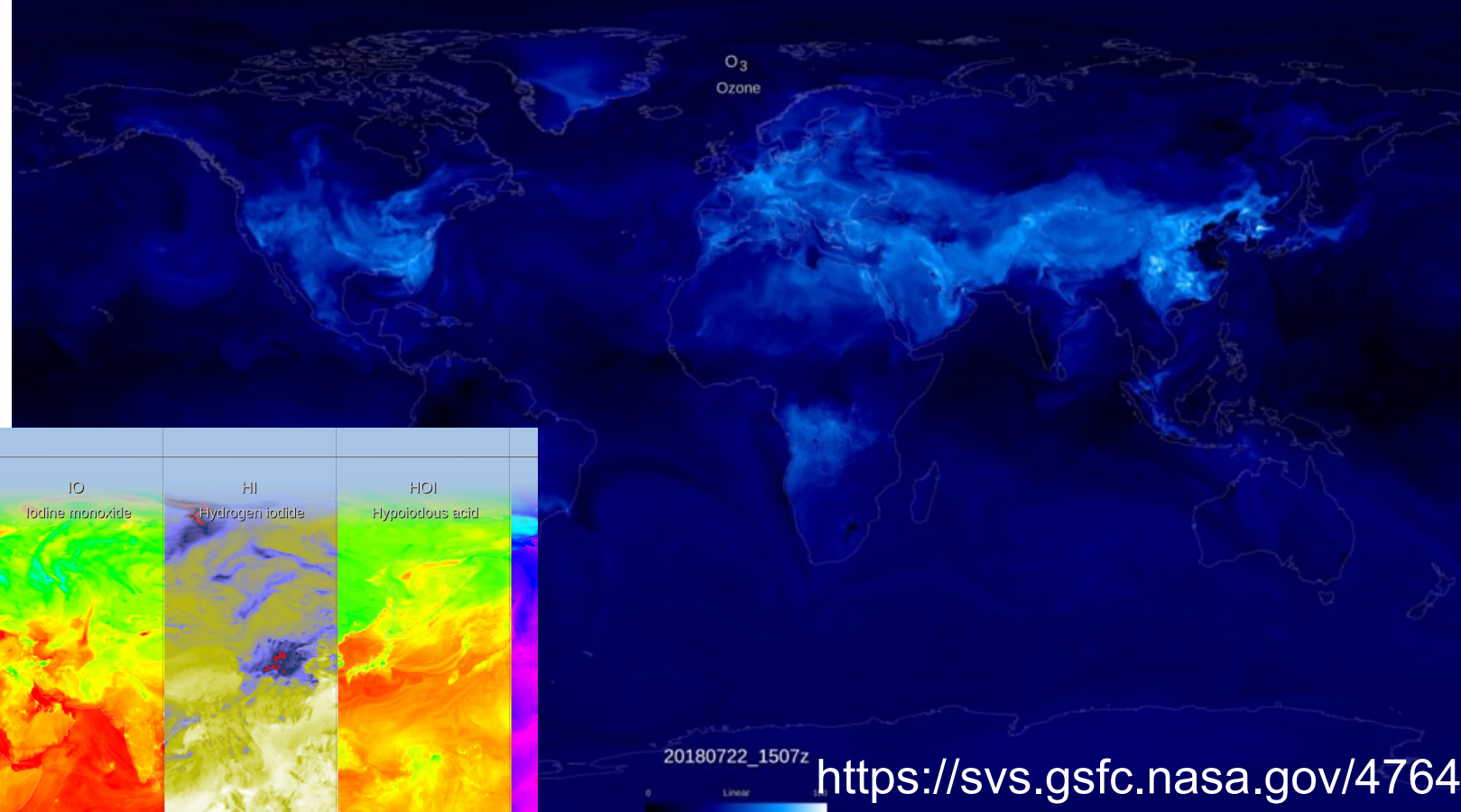
15 February 2022



GEOS - CF

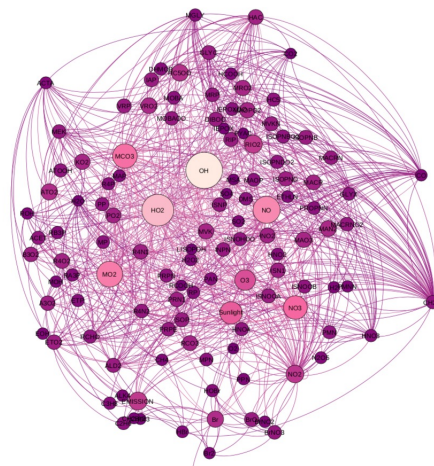
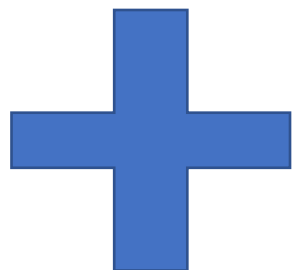
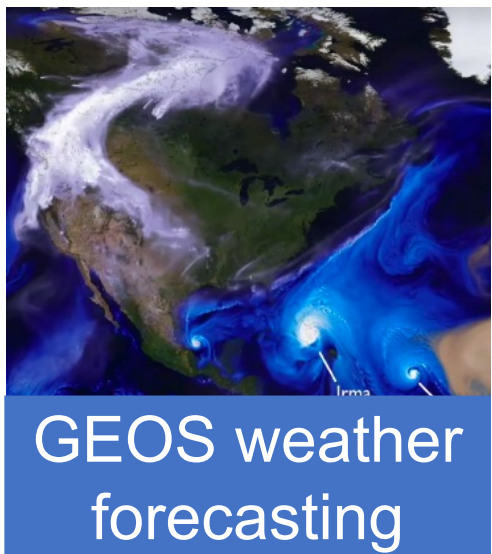


<https://svs.gsfc.nasa.gov/4754>

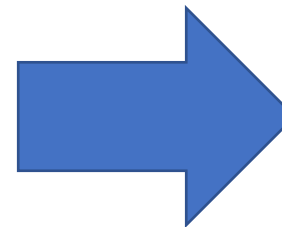


Global historical model estimates and daily 5-day forecasts of major air pollutants like Ozone & PM_{2.5}

GEOS Composition Forecast



GEOS-Chem



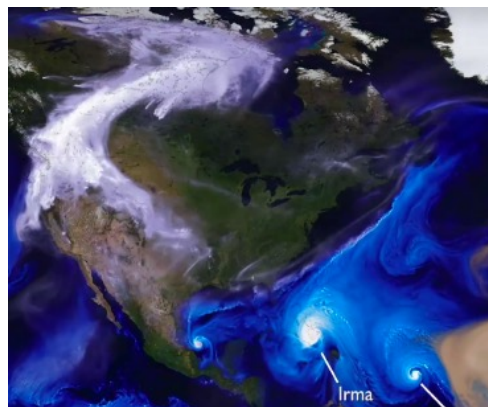
GEOS - CF

Version 12

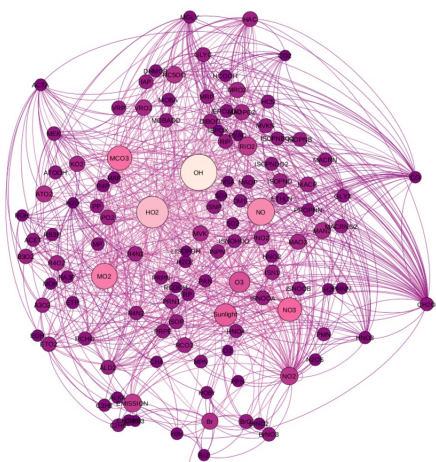
Tropospheric and Stratospheric chemistry

- 250 Chemical Species
- 725 Chemical Reactions

Daily composition forecast



GEOS NWP



GEOS-Chem

GEOS - CF

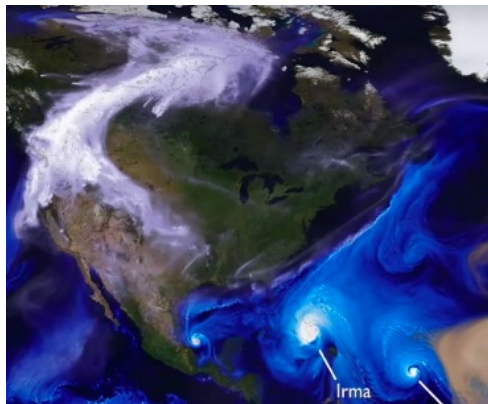
One **5-day forecast** per day

- Initialized at 12z
- 1-day meteorological replay (“analysis”)
- 5-day forecast
- 25x25 km² resolution, 72 model layers
- Chemistry: O₃, NO_x, PM, CO, VOCs, ...
- Meteorology: T, U, V, RH
- Since January 1, 2018

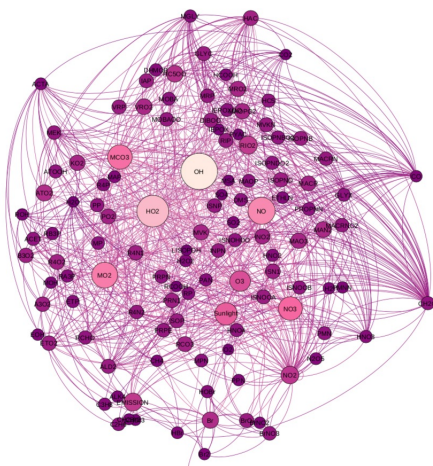
Emissions:

- HTAP (global bottom-up) for anthropogenic
- Near real-time fires (QFED)
- Online dust, sea salt, plant emissions

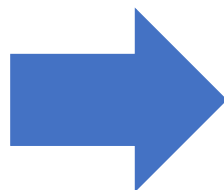
Chemistry is not cheap!



GEOS NWP



GEOS - Chem



GEOS - CF

Run on **NASA's** Center for Climate Simulation **supercomputer**

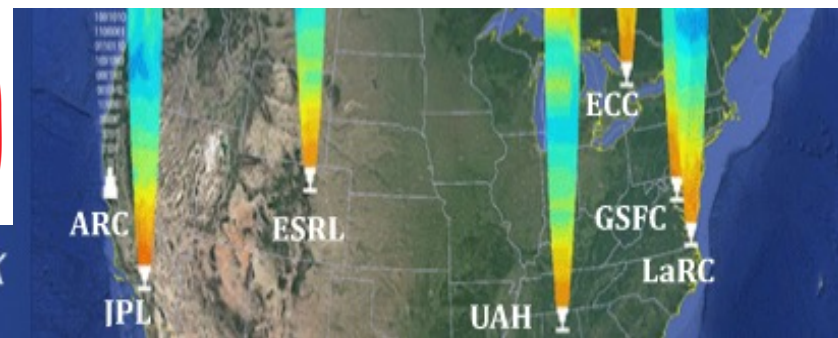
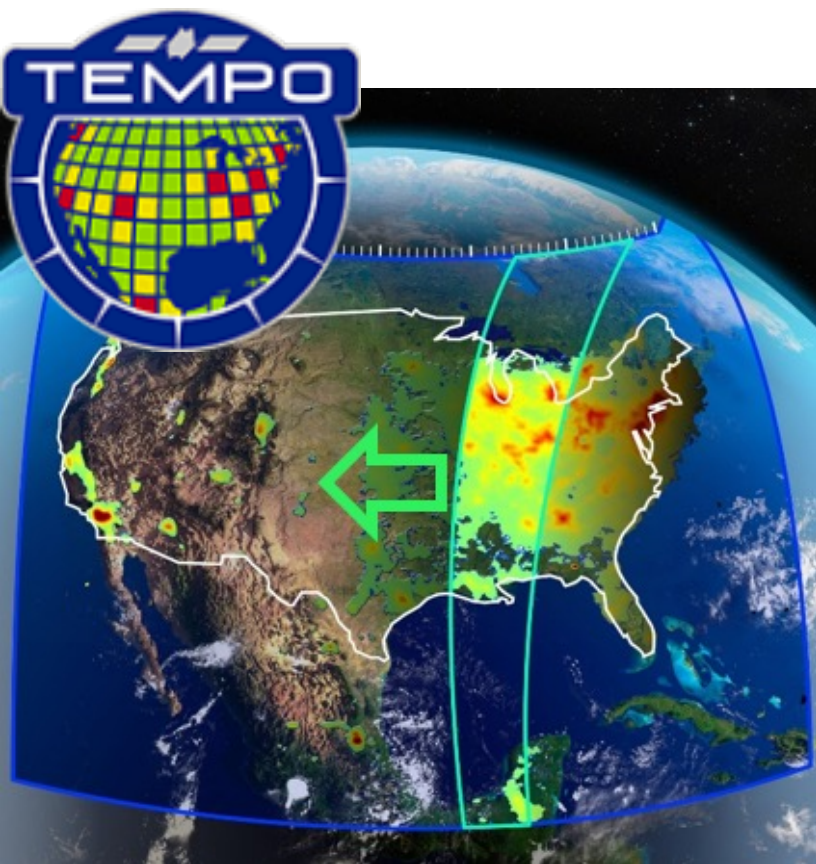
- using the computing power equivalent to **3500** personal computers.

Daily *atmospheric composition* forecast

GEOS - CF

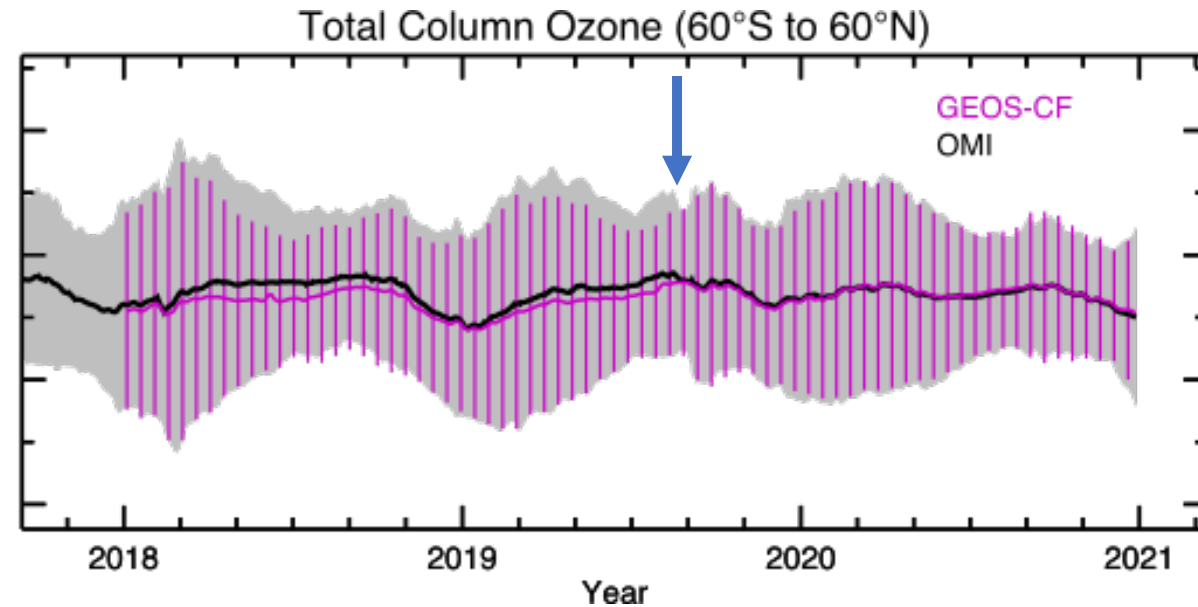
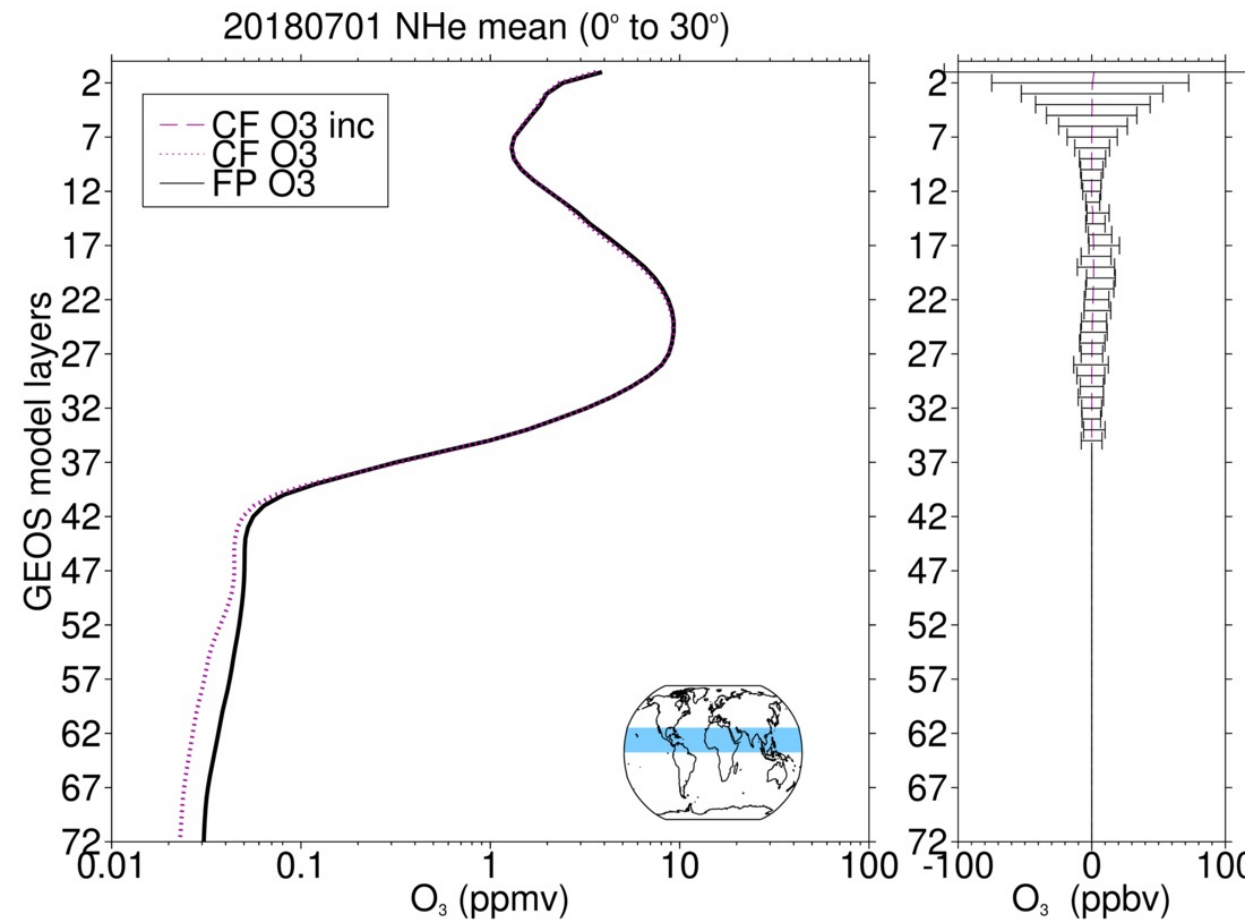
A realistic stratosphere in GEOS-CF is essential to support a broad range of NASA applications, including:

- Satellite retrievals of trace gases
- Airborne campaigns
- Stratosphere-troposphere exchange



Near-real time updates from satellite data

- GEOS-CF Stratospheric O_3 is weakly nudged to the GEOS FP assimilated O_3

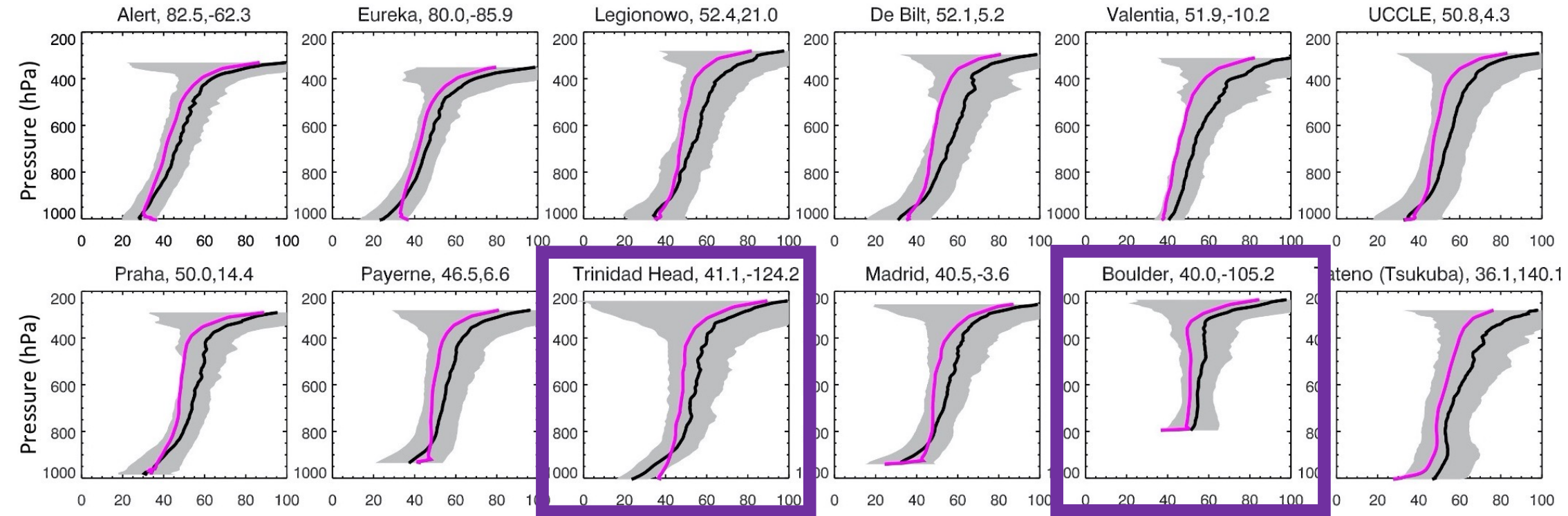


GEOS-CF captures the spread of OMI column O_3 especially after updates are made in August 2019

Knowland et al., JAMES, *under review*

GEOS-CF ozone compares well against ozonesondes

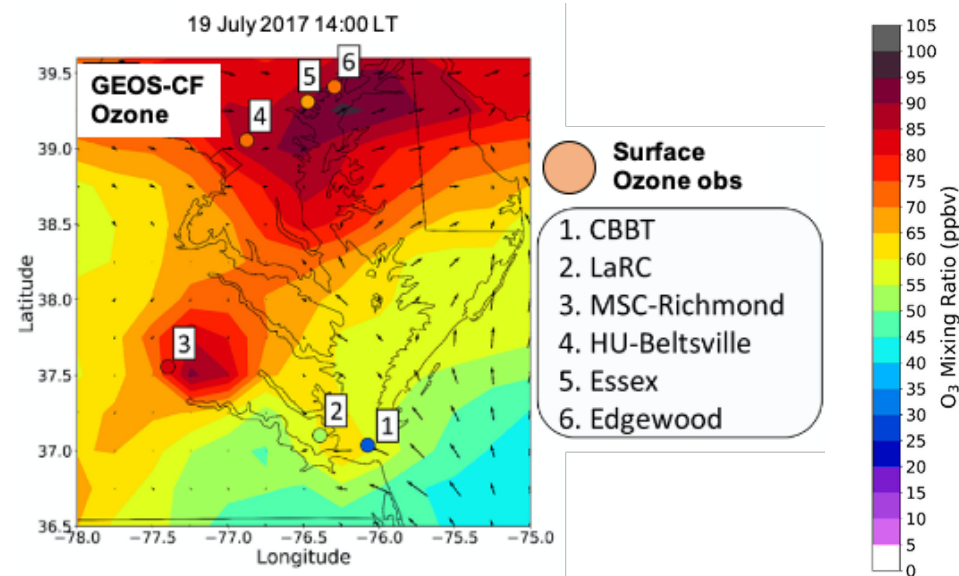
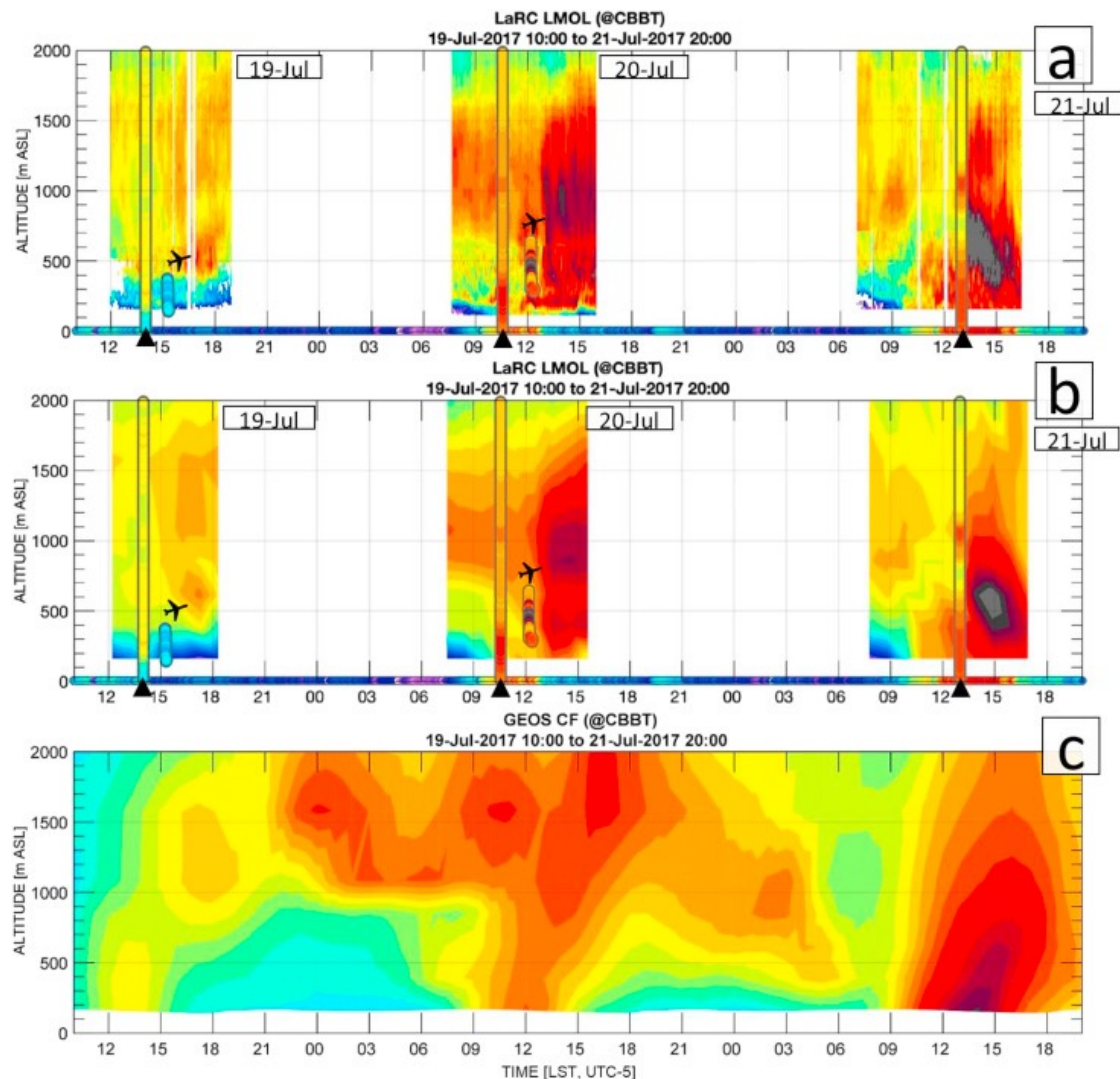
Annual average 2018-2019



■ Sondes ■ GEOS-CF

Keller et al., 2021 JAMES

GEOS-CF evaluation with NASA's OWLETS campaign observations

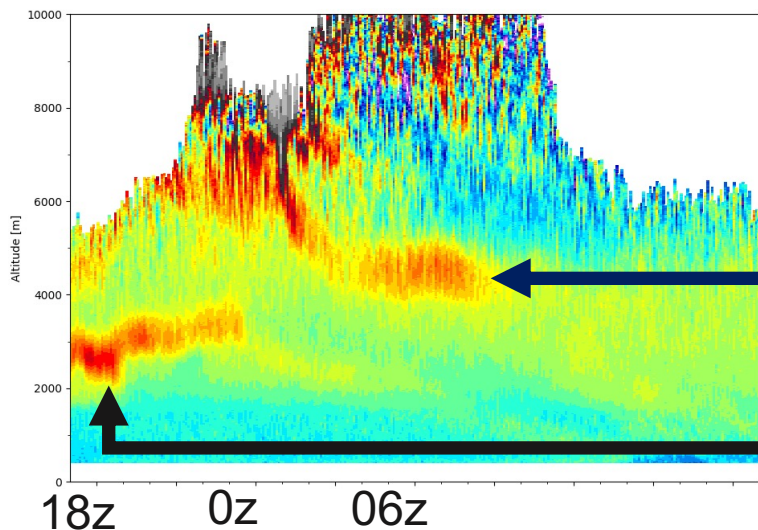


Dacic et al. (2020) used the GEOS-CF simulated ozone to put the OWLETS observations in ‘the big picture’, using the combined meteorology and chemistry to represent the synoptic conditions that lead to the observed ozone exceedances at surface observation sites.

Dacic, N. et al., 2020, Atmos. Environ. “Evaluation of NASA’s high-resolution global composition simulations: Understanding a pollution event in the Chesapeake Bay during the summer 2017 OWLETS campaign”

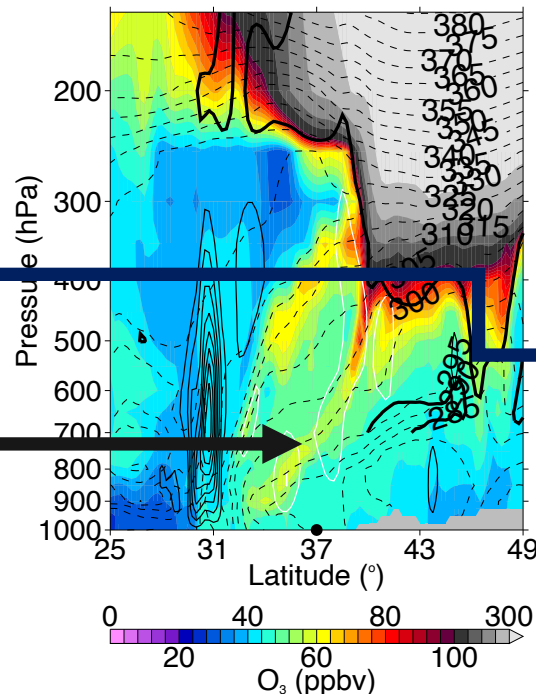
Stratosphere Troposphere Exchange

NASA LaRC Feb 13-14, 2019

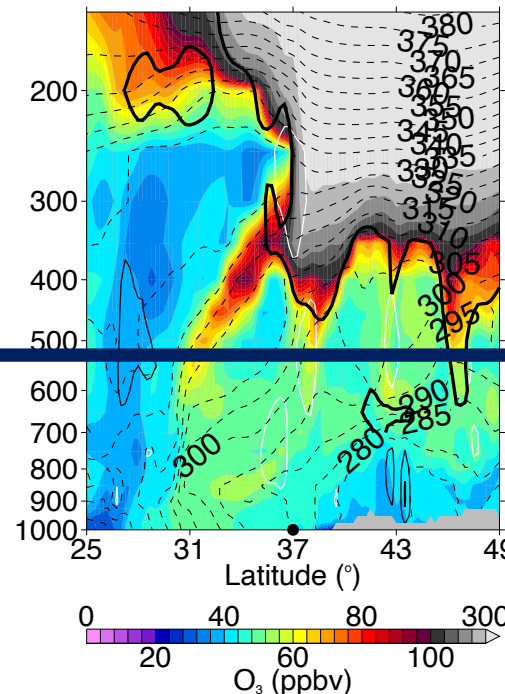


TOPAZ lidar plot courtesy of G. Gronoff

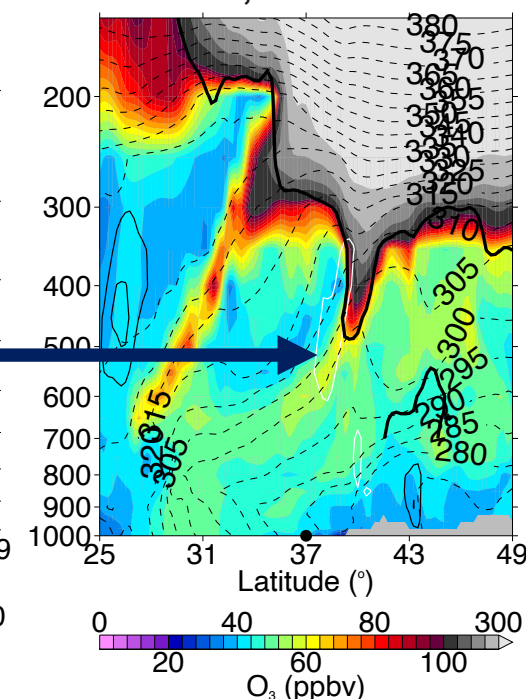
GEOS-CF
Feb 13, 2019 18z



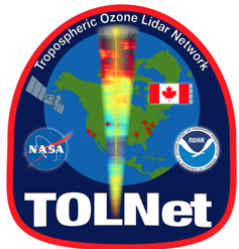
Feb 14, 2019 00z



Feb 14, 2019 06z



Gronoff, G., T. Berkoff, K. Knowland, et al. 2021. "Case study of stratospheric Intrusion above Hampton, Virginia: lidar-observation and modeling analysis." Atmospheric Environment, 118498 [10.1016/j.atmosenv.2021.118498]



GEOS-CF are available online in near real-time

FLUID is a mobile-friendly website

<https://fluid.nccs.nasa.gov/cf/>

Composition Forecast

CF Datagrams

NATIONAL

Select a Station

WORLD

Select a Station

AERONET

NORTH AMERICA

TMF

MEGACITIES

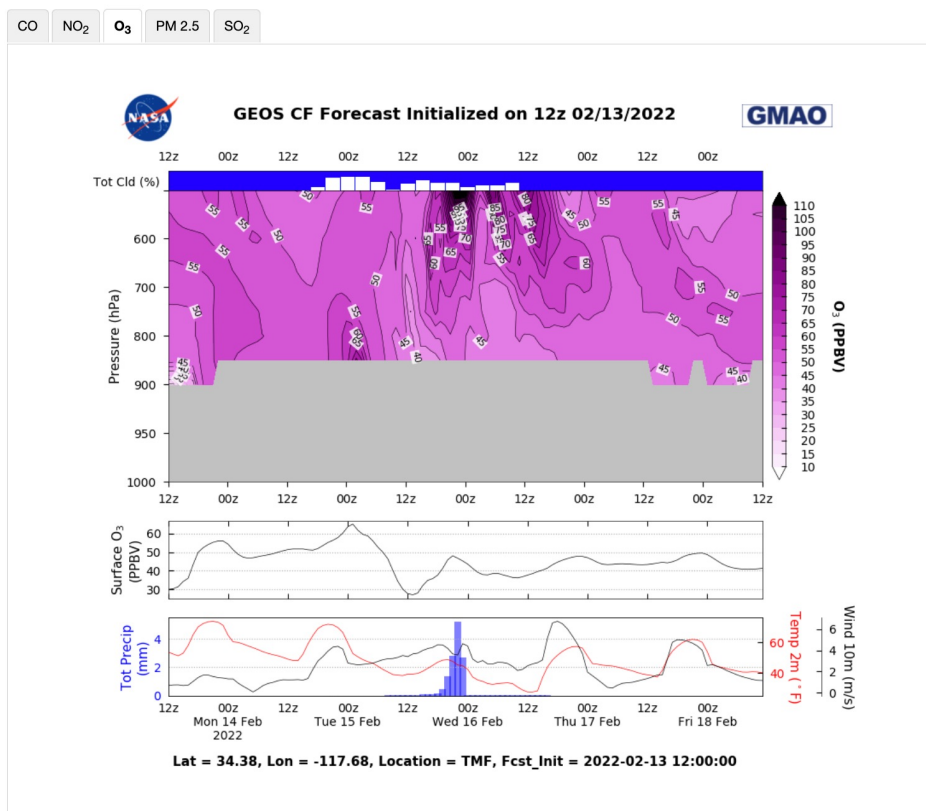
Select a Station

ACTIVE CAMPAIGNS

Select a Station

GMAO GEOS CF Datagrams

O3 at TMF (34.38, -117.68)



<https://portal.nccs.nasa.gov/datashare/gmao/geos-cf/v1/>

GODDARD SPACE FLIGHT CENTER

[+ NASA HomePage](#)
[+ NASA Center for Climate Simulation](#)

NCCS Dataportal - Datashare

Name	Last modified	Size	Description
Parent Directory		-	
das/	26-Aug-2019 10:41	-	
forecast/	22-Mar-2019 13:49	-	

[+ Privacy Policy and Important Notices](#)

Curator: Corey D Jones
 NASA Official: Dan Duffy
 Last Updated: 03/13/2019

<https://opendap.nccs.nasa.gov/dods/gmao/geos-cf/>

GrADS Data Server - info for /gmao/geos-cf/assim/chm_tavg_1hr_g1440x721_v1 : [dds](#) [das](#)

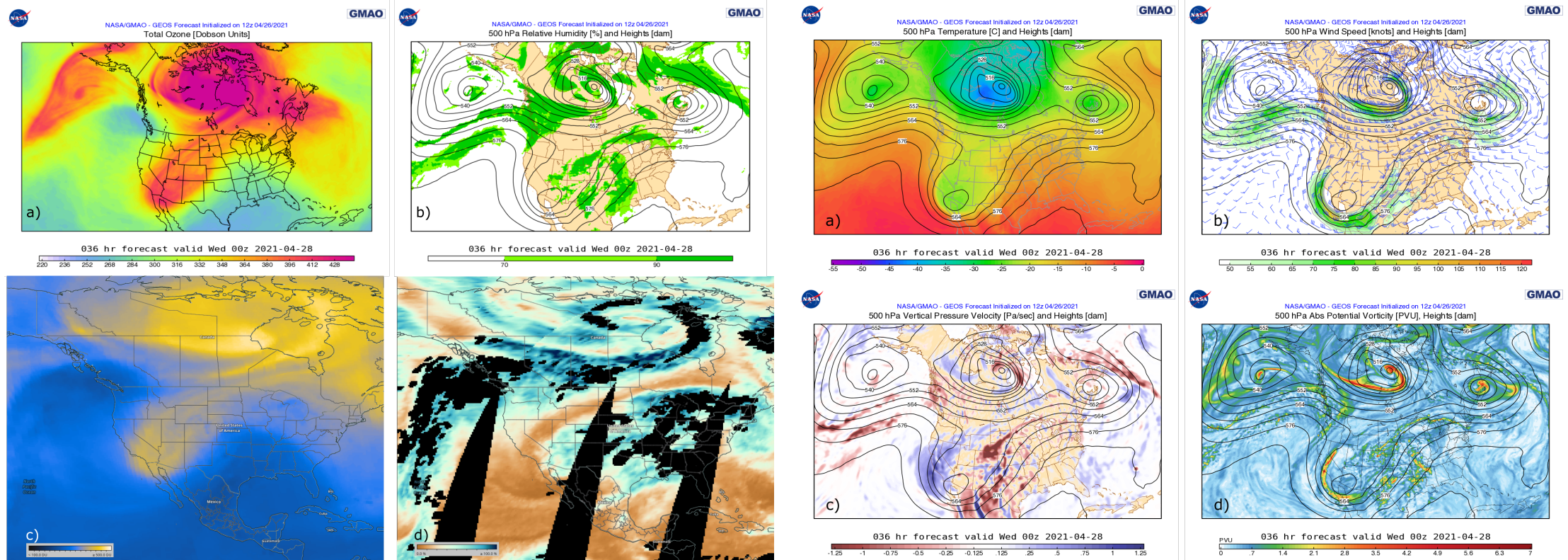
OPeNDAP/DODS Data URL: https://opendap.nccs.nasa.gov/dods/gmao/geos-cf/assim/chm_tavg_1hr_g1440x721_v1

Description: GEOS CF (Composition Forecast)
Documentation: (none provided)
Longitude: -180.0000000000°E to 179.7500000000°E (1440 points, avg. res. 0.25°)
Latitude: -90.0000000000°N to 90.0000000000°N (721 points, avg. res. 0.25°)
Altitude: 72.0000000000 to 72.0000000000 (1 points)
Time: 00:30Z01JAN2018 to 11:30Z31OCT2019 (16044 points, avg. res. 0.042 days)
Variables: (total of 52)
xyle xylene (c8h10, mw = 106.16 g mol-1) volume mixing ratio dry air
dst2 dust aerosol, reff = 1.4 microns (mw = 29.00 g mol-1) volume mixing ratio dry air
hno4 peroxyntiric acid (hno4, mw = 79.00 g mol-1) volume mixing ratio dry air
pm25su_rh35_gcc sulfate_particulate_matter_with_diameter_below_2.5_um_rh_35

Duncan et al. (2021) GeoHealth

Section 3.3.3 Stratospheric influence on Surface AQ

- Description on how to use GMAO's FLUID and NASA Worldview website to diagnose Stratospheric Intrusions using combination of GEOS products and satellite observations

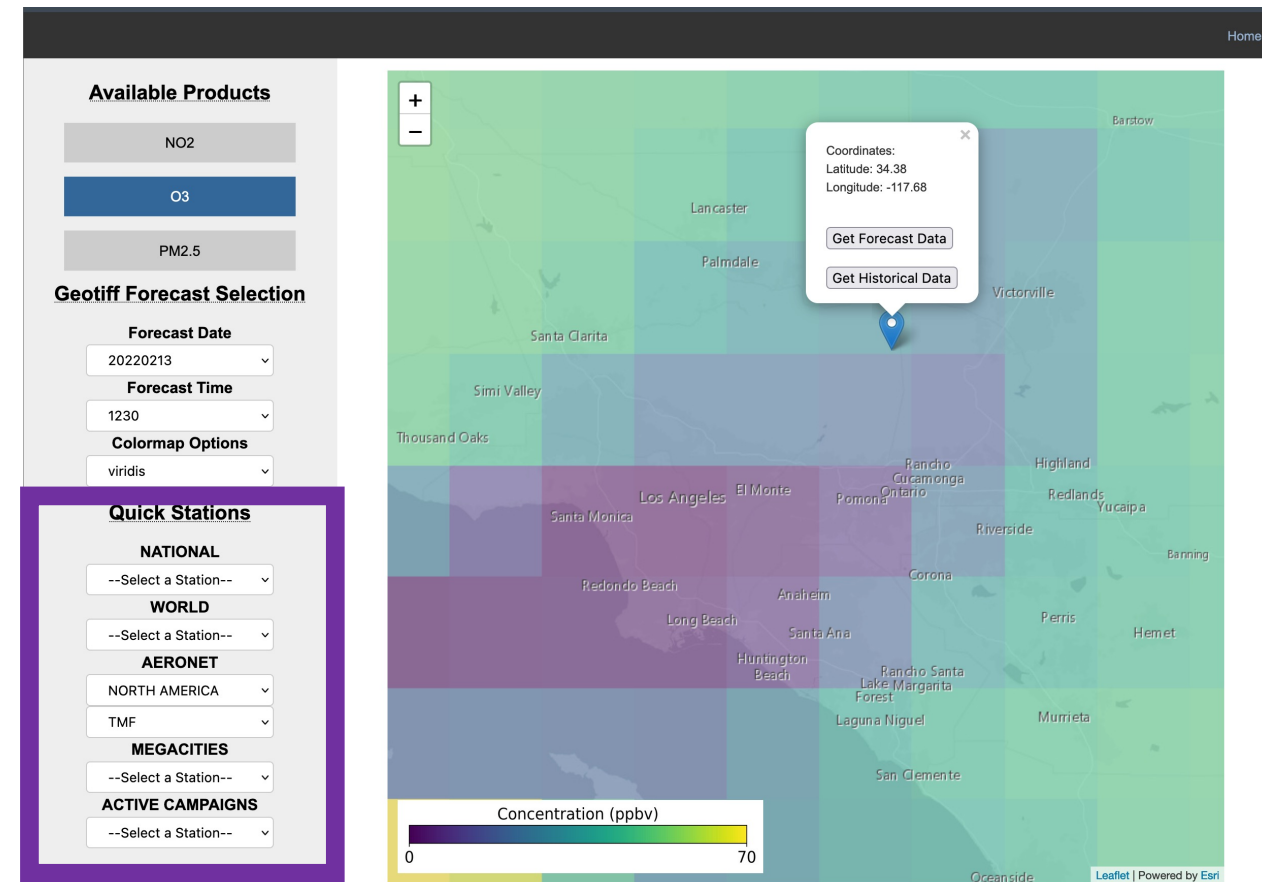
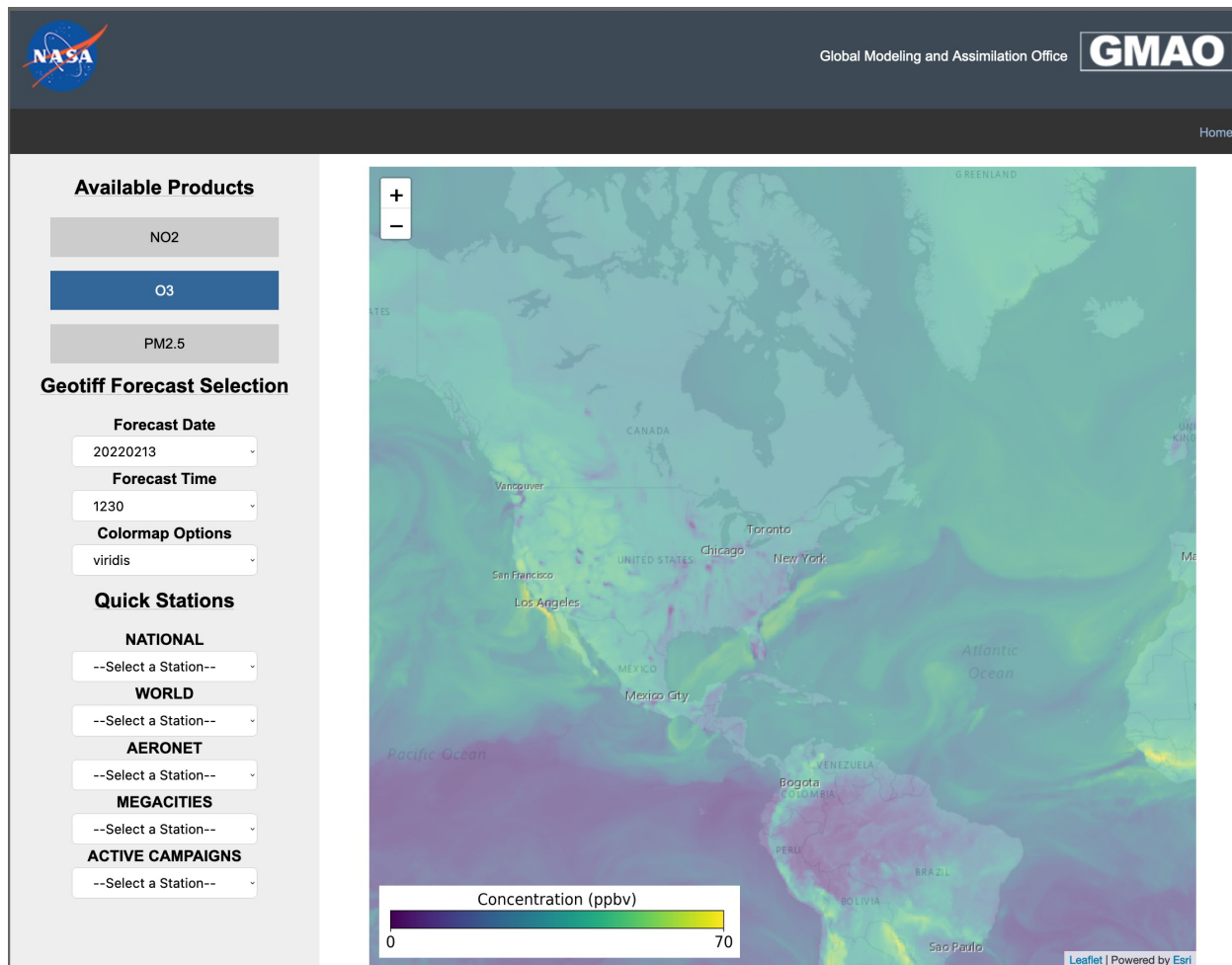


Duncan, B. N., C. A. Malings, K. E. Knowland, et al. 2021. "Augmenting the Standard Operating Procedures of Health and Air Quality Stakeholders With NASA Resources." *GeoHealth*, 5 (9): [[10.1029/2021gh000451](https://doi.org/10.1029/2021gh000451)]

Emerging FLUID Features *in Development*

Capability to zoom in and select data for any grid box

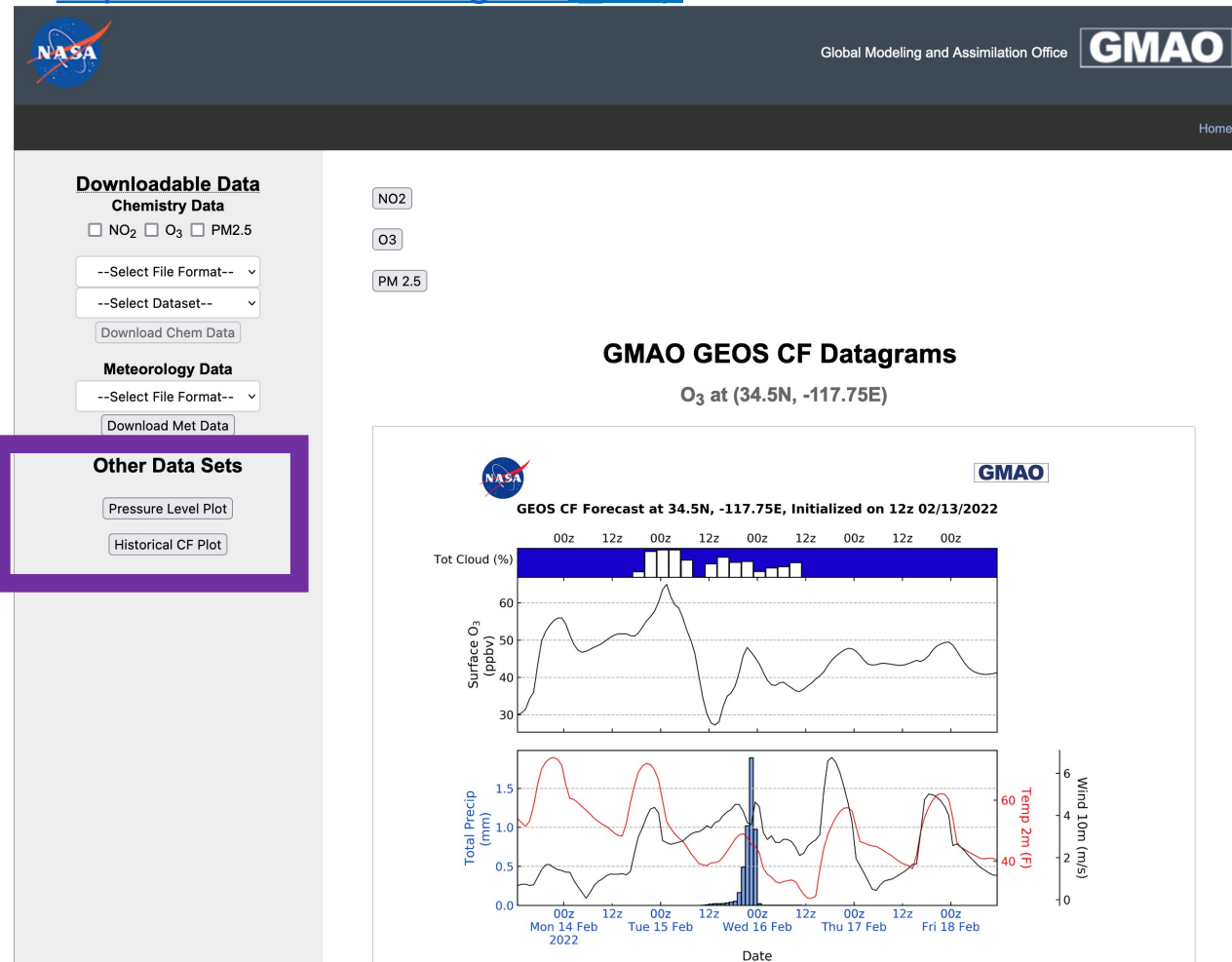
https://fluid.nccs.nasa.gov/cf_map



Emerging FLUID Features *in Development*

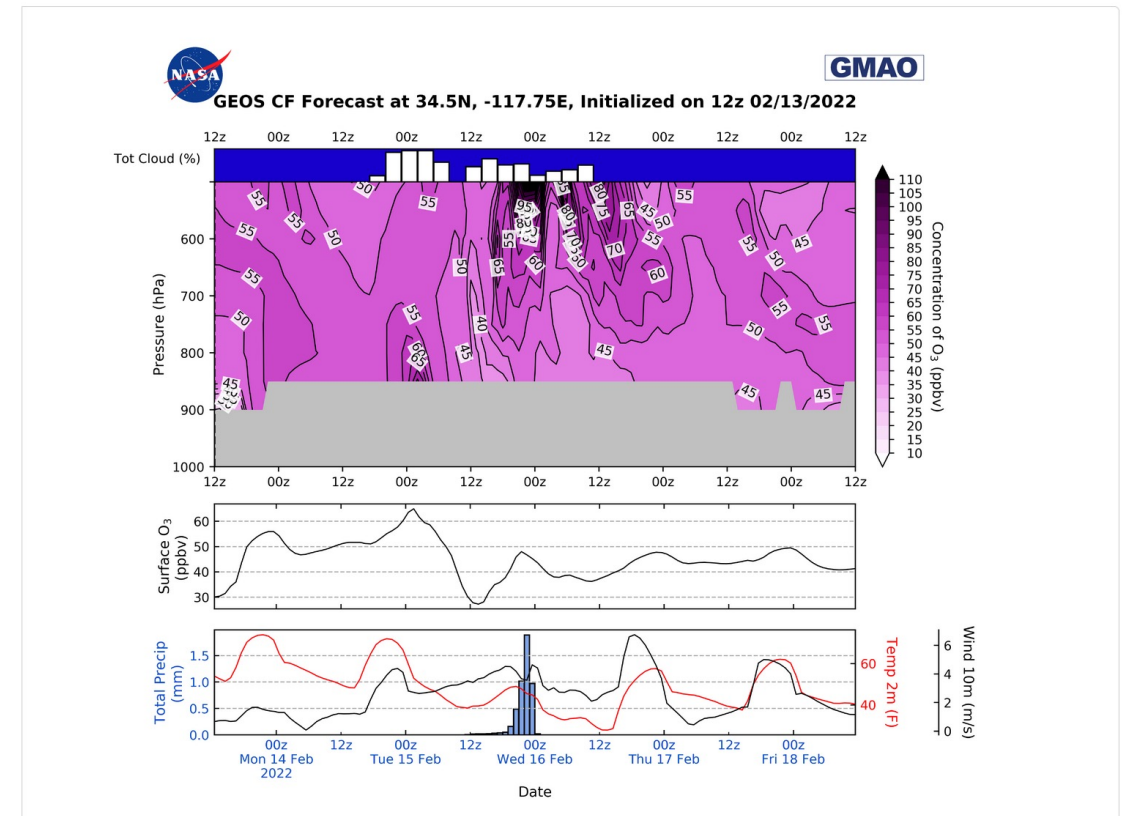
Capability to zoom in and select data for any grid box

https://fluid.nccs.nasa.gov/cf_map



GMAO GEOS CF Datagrams

O₃ at (34.5N, -117.75E)



Summary

GEOS-CF produces daily global air quality forecasts at 25km (16 miles) horizontal resolution since 1 January 2018

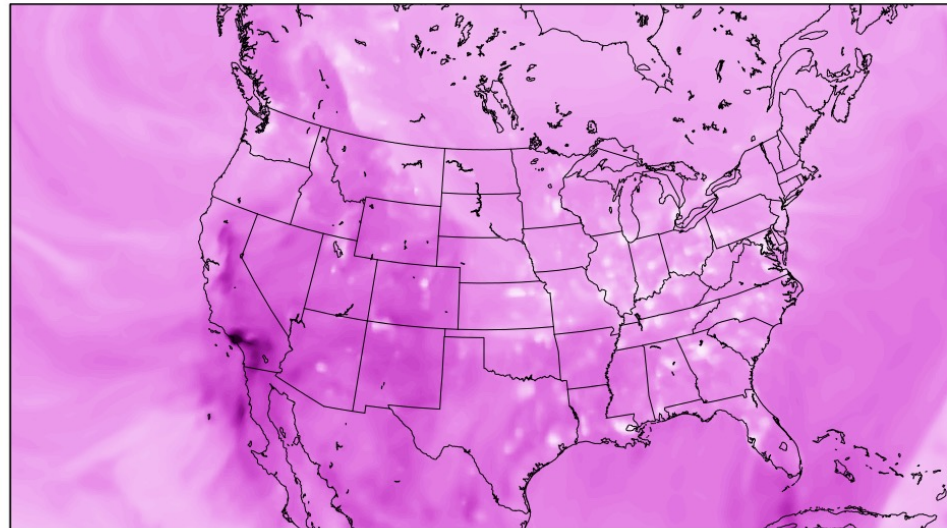
- AQ maps and data access fluid.nccs.nasa.gov/cf
- Forecast anywhere in the world fluid.nccs.nasa.gov/cf_map



NASA/GMAO - GEOS CF Forecast Initialized on 12z 02/13/2022

GMAO

Surface O₃



036 hr forecast valid Tue 00z 2022-02-15

[PPBV]

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

